barely make expenses during the next few years, and, second, that it costs more to operate vessels under the American flag than under other registries. The latter statement is no hasty generalization, but is based on the experience of one of the largest American companies which operates ships under several flags.

It is not the purpose to go into the complications of the problem but rather to refer to the biblical king who, before going to war, sat down and calculated the cost. It is a question of the game being worth the candle, of whether the collateral and intangible benefits will compensate for the low direct financial return, and, if not, of whether we are willing to support subsidies.

One is pessimistic of the future of our shipping mainly because of popular misconceptions and the apparent belief of a democracy that we can have anything, even a large merchant fleet, merely by talking about it. In such a situation it is helpful to state the problem, the solution of which is far from hopeless. Certain specific remedies will be discussed elsewhere.

E. S. Gregg

SCIENTIFIC METHOD IN JOB ANALYSIS

One of the most popular subjects now engaging the attention of industrial executives is job analysis, which is generally conceived as a process of dissecting a job and describing its component elements. An examination of the usual factory procedure shows that this dissection is usually accomplished by means of rough observation on the part of the employment manager in consultation with foreman, master mechanic, or expert operator. The "unit operations" thus revealed are then written up in a form called the job specification. These attempts at analysis yield results of some value, but they fail to bring to industry all the benefits potential in analysis because they are too rough and too nearly matters of rule of thumb.

Two improvements in particular should be adopted. First, the observations should be made not merely with the naked eye but also with microscopic minuteness. Granted that rough and ready divisions are adequate for certain situations, still to stop with them would be as fallacious as to confine the study of the human body to the technique of gross anatomy. Just as the science of human anatomy in the course of its development was obliged to adopt the microscope and to make

minute differentiation between structures, so must job analysis proceed to divide the job into its very minute elements.

The necessity for this appears more cogent when we reflect that employment managers are making strenuous efforts to analyze the individuals who apply for jobs, seeking to determine their qualifications in terms of general intelligence, special abilities, and trade proficiency.

However auspicious may be the prospect for ultimate success in connection with these test analyses of workers, one who is not too optimistically inclined must admit that we seem for the present to have reached an *impasse*. We do not see which way to turn. The writer ventures to suggest that the difficulty comes from the fact that we have been trying to describe the abilities of the individual without specifying what use he will have to make of them on the job. In our zeal for determining his reaction time we have failed to find out just what he will have to react to. Before we can succeed, therefore, in satisfactorily analyzing the worker we shall have to push our analysis of the job to a higher stage of refinement.

There are other reasons justifying more minute analysis of the job. We shall mention them presently. For the present let us note the second amendment which should be made to the current concept of job analysis: State the components of the job in quantitative terms.

To phrase these amendments briefly we may say, conduct job analysis according to the niceties of scientific method, by which is implied control of conditions, repeated observations, measurement of operations, tabulation of measures, and the drawing of conclusions.

In order to objectify this point of view and to illustrate the application of the method, a concrete case will be described, consisting of the scientific investigation of certain psychological phases of proofreading.

Persons engaged in the printing industry generally agree that proofreading requires some fundamental psychological quality without which one can hardly achieve success in the occupation. Perhaps it consists of some inborn ability; perhaps of certain acquired habits of perceiving the printed word. Probably it consists of a combination of abilities. It was to discover some of them that the investigation about to be reported was made.

The first phase investigated was the amount of work that might be expected of a proofreader working on this particular job under the conditions prevailing at the plant. This figure was secured by measuring the work done by operators on the job. Table I shows the records.

Though the extremes are far apart, as would be expected by one acquainted with the vast differences in human capacity, the figures show that we may demand of a proofreader of median efficiency that he read

TABLE I

SHOWING NUMBER OF LINES READ PER HOUR AND FREQUENCY WITH WHICH ERRORS WERE OVERLOOKED BY PROOFREADERS

Reader	Lines per Hour	Lines to 1 Error
A	1,278	...
B	1,157	...
C	1,020	57
D	934	34
E	903	35
F	899	...
G	889	47
H	886	...
I	874	...
J	827	...
K	677	21

at least 899 lines per hour. The records in accuracy for certain readers on this job were not available. From the records of a similar group engaged in this kind of work, however, we find that the median reader failed to detect one error in every thirty-five lines. See Table II.

TABLE II

SHOWING FREQUENCY WITH WHICH ERRORS WERE OVERLOOKED BY PROOFREADERS

Reader	Lines to 1 Error
A	65
B	47
C	45
D	35
E	34
F	20
G	20
H	16

Our analysis shows that better standards than these are possible. By the use of good methods some readers attain a speed one-third better than the standard just mentioned, and a degree of accuracy almost twice as great.

This gives us a cue to the next point to be investigated, namely, the methods used by the best workers. Among the many aspects of their work which may be examined, surely one of great importance is eye movement. Accordingly the next point of attack was the analysis of the eye movements of the good and poor proofreaders and the investigation of differences between them.

Thanks to the voluminous investigations that have centered upon ordinary reading during the past twenty years, there was available a technique for making such measurements, and with it were measured the eye movements made by good and poor proofreaders; results were tabulated with respect to number of pauses and length of pauses.[1]

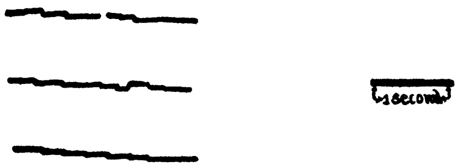

FIG. 1.—Record of eye-movements made by good proofreader reading three lines (assisted by copyholder).

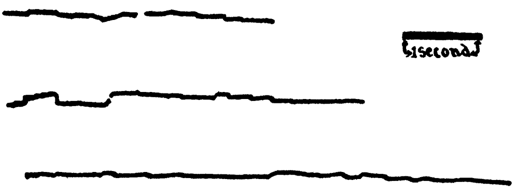

FIG. 2.—Record of eye-movements made by poor proofreader reading same three lines (assisted by copyholder).

It is well established that reading proceeds by means of a number of eye jumps and pauses on significant portions of words. Measurement of the extent of these jumps and the length of the pauses is made by means of a moving photographic film upon which is photographed a ray of violet light reflected into and out of the reader's eye. The light is interrupted every fiftieth of a second by a tuning-fork vibrating at that rate. Thus the eye movements are recorded on the film as a series of small dots, each dot representing one-fiftieth of a second. Figures 1 and 2 are reproductions of sample photographic records of eye movements

[1] For assistance in making these photographic records the writer gratefully acknowledges the co-operation of Mr. C. T. Gray and the custodians of the apparatus furnished to the School of Education of the University of Chicago by the General Education Board.

made by good and poor proofreaders respectively, while reading the same three lines of type. (The material was read aloud by a copyholder.) The dots representing fiftieths of a second are not here shown, but the time-intervals may be gauged by means of the adjoining second-scale. Table III shows the average number of pauses and the average length of pauses in fiftieths of a second, made by a good and a poor proofreader reading the same twelve lines. (This material also was read aloud by a copyholder.)

TABLE III

	Average Number of Pauses per Line	M. V.*	Average Length of Pauses	M. V.*
Good........	7.4	.48	17.1	1.66
Poor.........	11.0	2.00	19.3	3.64

* Mean Variation, i.e., the average of the amounts by which the separate measures deviate from the average.

From these results we may draw the following conclusions: (1) a good reader makes on the average fewer pauses than a poor one—7 *vs.* 11. (2) A good reader makes on the average shorter pauses than a poor one—17 *vs.* 19. (3) A still more important matter is the demonstration of differences in regularity. The good proofreader reads very regularly. His eye movements are so regular as to be almost rhythmic, with respect to both length of line and number of pauses. The poor proofreader, however, reads irregularly. These differences may be quantitatively stated in terms of the mean variations shown in Table III. The small mean variations in the record of the good reader indicate that he paused practically the same number of times in each line—on the average no more than eight (7.4+.48) times, and no less than seven (7.4—.48) times. The poor reader, however, paused on the average as many as thirteen (11.0+2.0) times and as few as nine (11.0−2.0) times. In length, the pauses varied between 18.8 and 15.4 in the case of the former, and between 22.9 and 13.7 in the case of the latter.

This report should not be regarded as a complete analysis of proofreading. Such an analysis would involve measurements showing the physical demands and conditions of the job; the economic conditions such as rate of pay to be expected at the end of six months, one year, five years, twenty years; the kind of promotion to be expected; the hygienic effects, such as eye strain, longevity, and the like; and finally, a far more detailed statement of the psychological factors concerned:

the degree of intelligence required, the emotional requirements and effects, kinds of imagery. The measures presented above are given merely in order to illustrate the twofold thesis of the paper: (1) that job analysis should be made a matter of more minute analysis than it is at present; and (2) that it should consist of quantitative rather than merely qualitative statements.

Such scientifically validated analyses may be found useful in the following ways.

1. They may be used by the employment manager as the complement of the measurements which he seeks to make of applicants for positions, furnishing an intelligible and concrete pattern into which the analyzed abilities of the applicant may be fitted. They may also assist in the arrangement of harmonious grades and routes of promotion. It is becoming the practice in business establishments to chart job routes over which satisfactory employees may expect to pass on their way from a lower job to a higher one. Now there is considerable overlapping in the duties and qualifications appertaining to various jobs, and job analysis may show at what stages workers traveling various routes may be interchanged. In fine, by discovering the elements of the job, the employment manager may more accurately fit the individual to the job, thus discharging his twofold duty of vocational selection and vocational guidance.[1]

2. The educational director may utilize the results of job analysis in training new workers. For analysis of an operation at the various stages in the acquisition of skill may reveal the rate at which normal progress proceeds. If a learner does not attain the requisite skill at a given stage he may be removed from the job before much time and energy are wasted in the effort to train him.

3. The production manager may use this technique in discovering the wastes that infest an operation, and may devise more efficient methods of doing the work. Having developed better methods, he may set up higher standards of performance, and may establish more equitable wage-scales.

4. With such accurate measurements of the factors entering into a job the cost accountant may distribute the elements thereof and may estimate more accurately the cost of new jobs about to be contracted for.

[1] See H. D. Kitson, "Employment Managers as Vocational Counselors," *Industrial Management*, LXI (March 1, 1921), 211.

Serving as it does such a variety of functions, job analysis looms up as one of the truly important practical problems in the intensive cultivation of our industrial resources; and it holds forth promise of richly justifying all the efforts that we may put forth in making it scientific.

H. D. Kitson

Indiana University

THE DANISH TECHNOLOGICAL INSTITUTE

In Copenhagen there is a unique school for craftsmen and lesser manufacturers called the Technological Institute. It is situated on the old ramparts and fortifications of the city and is regarded by its ardent patrons as the defense and castle of modern Danish industry and handicraft.

The aim of the school is the furtherance of skilled handicraft among Danish artisans. The end is sought by five different means:

1. By instruction (lectures and courses) of a professional and mercantile character.
2. By a system of consultation and of experimental research.
3. By arranging professional meetings and professional exhibitions.
4. By the publishing of technical manuals.
5. By a technical library whose use is free to all tradesmen.

The Institute receives half of its support from state grants and the other half from donations by employers' and business organizations, endowments, and fees derived from instruction and consultation. The Institute is administered through a council consisting of representatives from the state and from the supporting organizations.

To attend the Institute's courses it is necessary that the students be master-mechanics or journeymen. The Institute does not assist in the training of apprentices. That training takes place in private workshops and in the technical schools provided by the state. The Institute may be regarded as giving a postgraduate type of instruction to men who are already acquainted with the fundamentals of their trade. The instruction takes place partly in the workshops, where the student has the use of the newest machines and tools in the trade, partly in the classrooms, and partly through visits to large technical works. Courses last from one to seven weeks, varying with the subject. But a course pursued only in night classes requires about two years for completion.

The effort is made to secure the finest experts available for instructors. The staff includes engineers, chemists, and highly skilled craftsmen.

Lesser employers find it an immense advantage to have the opportunity of acquainting themselves with the latest methods and inventions and of trying out various kinds of machines to ascertain the type most suitable for their purpose. The state even grants assistance in the form of cheap loans to worthy master-mechanics who desire to purchase new and up-to-date machines.

The consultation service of the Institute is perhaps the most popular feature. Journeymen and masters may write to the Institute for any trade information and have their questions answered by experts. Extended research is often necessary before the question can be solved. For this service the Institute charges a nominal fee. Craftsmen also make extensive use of the Institute's library, which endeavors to have on file the latest professional works and papers.

The general public, as well as craftsmen, may at any time visit the exhibition hall of the Institute, where there are presented new or efficient materials and machines of interest to industry and handicraft. On special occasions more extensive exhibitions are arranged, such as the huge Örsted Exhibit of electrical appliances which was held last year.

The school was brought into existence in 1906 at the initiative of "The Representatives of Danish Industry and Handicraft" and was put in charge of Professor Nyrop. Mr. Gregersen was appointed director of courses. In 1907–8 the Institute had its first grant in the State Bill of Finance. The school thus subsidized began work in 1908 in rooms which the "Society of Arts" in Copenhagen put at its disposal. The rapid growth of the institution since 1908 is apparent from the following table:

Year	Number of Pupils	Balance	Staff of Teachers	Area of the Establishment (Sq. M.)	Income	Endowment
1907–8	272	$ 1,600	6	500	$ 3,800	$ 2,500
1919–20	3,199	216,000	38	12,000	560,000	90,000

When the first group of students assembled there were offered courses only in wood and metal work, to which soon afterward were added bookkeeping, testing of materials, chemistry, and motor instruction.

The most important of the trades in which instruction is given in the Institute are those of machinists, smiths, welders, tool-makers, gas-fitters, plumbers, motor-mechanics, carpenters, joiners, cabinet-makers, carriage-makers, upholsterers, tailors, boot-makers, watch-makers, foresters, gardeners, and chimney-sweeps.

The steady expansion of the Institute from the date of its founding necessitated more room than the Society of Arts was able to provide. In 1912 the municipality was induced to grant a building site on the old fortifications of the city. The state appropriated money to begin building, plans were soon accepted, and the commission was let. Other financial aid became necessary before the building was finally completed, due to the price rise of the period. Finally, in 1918 the dedication of the building of the Technological Institute took place in the presence of the King of Denmark.

In addition to lecture-rooms, to workshops for every trade, and to exhibition halls, the Institute contains many laboratories for consultative research in chemistry and electricity, as well as experiment stations for paint, baking, tanning, and soap. There are generous offices for the directors, engineers, and the instructors, a large library, and several consulting-rooms. The building even contains a covered court where the newest agricultural machinery is exhibited, so that farmers who come from the provinces during the winter may be instructed in its use and care. The purpose has been to bring the latest thought and methods to any Danish industry which has a technological problem for solution.

Reaching its greatest influence as it did during the Great War, the Institute has not yet had an opportunity to become widely known. For the past six years European and American industry has had its attention upon too many more pressing problems to grasp adequately the significance of such an interesting educational development. However, this system, which provides an advanced training course for skilled workers, has possibilities for adoption by municipalities as well as by industrial states, or by particular groups of industries with similar technology and problems. The scheme of the Technological Institute may even contain germs of an idea for apprentice training. It will doubtless be recognized that Denmark has produced a real contribution to the progress of industrial education.

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